LEVEL III

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COMPARISON OF SIDE-BY-SIDE AND APPARENT-MOTION DISPLAYS FOR TARGET CHANGE DETECTION

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6 COMPARISON OF SIDE-BY-SIDE AND APPARENT-MOTION DISPLAYS FOR TARGET CHANGE DETECTION . Addendum.

C. L. Elworth, B. K. Gonzalez, [redacted] C. L. Klingberg
The Boeing Company

A. H. Birnbaum, Task Leader

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Submitted by:
Joseph Zeidner, Chief
Support Systems
Research Division

Approved by:
J. E. Uhlaner, Director
Behavioral Science
Research Laboratory

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NOTE

The study described in the present Research Memorandum was conducted as an addendum to two major experiments on change detection: (1) Change detection in aerial photo coverage as influenced by methods of comparison and (2) Effect of disparity in photo scale and orientation on change detection, published as TRN 205 and TRN 206, respectively. While the two modes of display--side-by-side and apparent motion--could not be evaluated directly from the data available, relative comparison of the two, as well as construction of the apparatus used, is of interest.

COMPARISON OF SIDE-BY-SIDE AND APPARENT MOTION DISPLAYS FOR TARGET CHANGE DETECTION

THE PROBLEM

This study was concerned with two display methods for the presentation of comparative-cover imagery for target change detection. The conventional side-by-side display, in which the two samples of imagery are simultaneously displayed in juxtaposition, was compared with a display system based on the application of the perceptual phenomenon known as "apparent motion." Apparent motion refers to the subjective appearance of motion experienced when certain types of pictorial stimuli alternately time share the same spatial location at specific temporal rates. In the present application, two aerial photographs of a given ground area, acquired at two different times, were aligned in an optical system so that they were alternately exposed to view. With imagery so displayed, unchanged areas appear static whereas changed areas appear to be in motion.

Limitations arise, however, in the application of apparent-motion display technique to change detection because any two aerial photographs of the same ground area may differ in many ways not associated with target changes of military significance. Differences associated with angles (shadows), seasonal changes, camera angles, aircraft altitude, and normal human activities of no military significance also will be revealed as changes between the early and later photos. These non-target changes constitute sources of "visual noise" which may be amplified in an apparent-motion display. Such noise can seriously diminish the potential advantages to be derived from the attention-demanding nature of motion, since interpreters must inspect each area of change before rejecting it as nonsignificant. In previous studies[1], the apparent-motion method was found in most cases to be superior to the side-by-side method, but as visual noise (irrelevant change) increased, superiority diminished and, in one case, the apparent-motion display even resulted in a significantly greater number of inventive errors.

Operation of the display equipment for apparent-motion presentation may be another source of difficulty, if alignment tolerances are too demanding to permit rapid insertion of the photos in the apparatus. Rectification of scale discrepancies may impose additional requirements on the design of display equipment.

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[1] Klingberg, C. L., C. L. Kraft, and C. L. Elworth. A Study of Photointerpreter Performance in Change Discrimination. RADC-TDR-63-482. Rome Air Development Center. 1963.

The present experiment was designed to explore change-detection performance with comparative-cover imagery displayed in side-by-side and apparent-motion modes, as controlled variations in scale differences and orientational misalignment were introduced in the imagery.

METHOD

EXPERIMENTAL DESIGN

The scales of the two images in each of 12 comparative-cover photo pairs were photographically adjusted to produce conditions in which the two scales either were the same or differed by 10 percent. In addition to these two scale disparity conditions, three degrees of rotary misalignment were also introduced: 0°, 2°, and 4°. The two scales and the three orientations were distributed equally between the two display modes, side-by-side and apparent-motion, as illustrated in the block diagram in Figure 1.

Twenty-four image interpreters each inspected the 12 photo pairs, half of which were displayed side by side and half in apparent-motion. The treatment-photo pair combinations were counterbalanced in two orthogonal Latin squares so that within each 12 x 12 matrix all photos were paired once with each mode. The combinations of photo pairs with modes of presentation are shown in Appendix A.

SUBJECTS

Twenty-four military image interpreters from the First Military Intelligence Battalion stationed at Ft. Bragg, North Carolina served as test subjects. Photointerpretation experience ranged from 1 to 132 months. All testing was conducted during regular duty hours at normal duty stations.

TEST MATERIALS AND EQUIPMENT

Photographs. Twelve pairs of photographs of the Camp Drum, New York area were selected from the film library at the U. S. Army's Behavioral Science Research Laboratory. Photo pairs were selected without specific reference to number or types of target and target changes present, but included a variety of terrain types. When "interpreter truth" data became available (Appendix B), the number of military targets present was found to range from 0 to 24, with four of the pairs containing no targets. Additional descriptive data on the characteristics (original scales, time lapses, image quality, etc.) of the selected imagery are presented in Table B-2 of the Appendix.

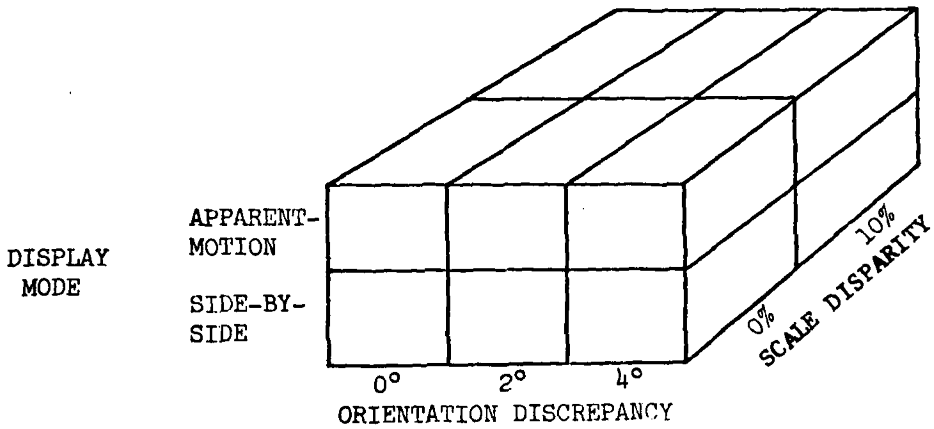

Figure 1. Schematic representation of experimental conditions.

The negatives of these photo pairs were cropped to include only the overlap areas, and positive black-and-white prints were produced. The original photo-scale discrepancies were rectified during reproduction to produce pairs of matched scale in a 4" x 4" format. A second print of one photo from each photo pair was then generated in a 3.6" x 3.6" format for the 10-percent discrepancy condition. These photos were individually mounted on precision machined plexiglass faceplates for controlled alignment within the display equipment.

<u>Apparatus</u>. The same presentation equipment was used for side-by-side and apparent-motion display modes. The major components are the display system and the timer and counter panel. The display system (shown in the cutaway diagram of Figure 2) uses two optical paths which combine to form a single field at the viewing aperture. The reference imagery is seen through a half-silvered mirror (M_2); reflected from the front surface of the mirror is the image from the comparison picture as it is reflected from another mirror (M_1). By adjusting the lateral positions of the two imagery mounting frames, the two photos may be seen in juxtaposition or superimposed.

Two circular 32-watt fluorescent lamps, 12 inches in diameter, were used to illuminate the photographic prints. These lamps were on simultaneously during the side-by-side presentations and alternately for apparent-motion presentations. The luminous output of each lamp is adjustable by controls I_r and I_1. The alternating frequency is regulated by control knob F_r. Overlap (time interval between turn-off of the reference light and turn-on of the comparison light) can be adjusted with control knob O_1 to obtain a condition where the decay of one light is matched with the rise of the other light so that no change in luminance level is apparent to the observer.

Also illustrated (Figure 2) are four control knobs for the alignment of imagery. Two of these, C_x and C_y, permit adjustment of the position of the comparison image in the vertical and horizontal axes, while the other two controls, C_d and C_z, permit change in depth (length of optical pathway) and rotary orientation of the reference image.

Switch S_1 provides power to the system. Switch S_2 is a double-throw momentary-contact toggle switch that permits the interpreter to interrupt the alternation of the lights for sustained viewing of either of the two photographs. Upon release, the switch returns to the center position and alternation is resumed.

During the data-gathering period, all controls remained fixed except for the power switch (S_1), the viewing mode selector switch (S_3), and the alternator interruptor switch (S_2) used by the subjects to stop the motion on either the early or the late photo.

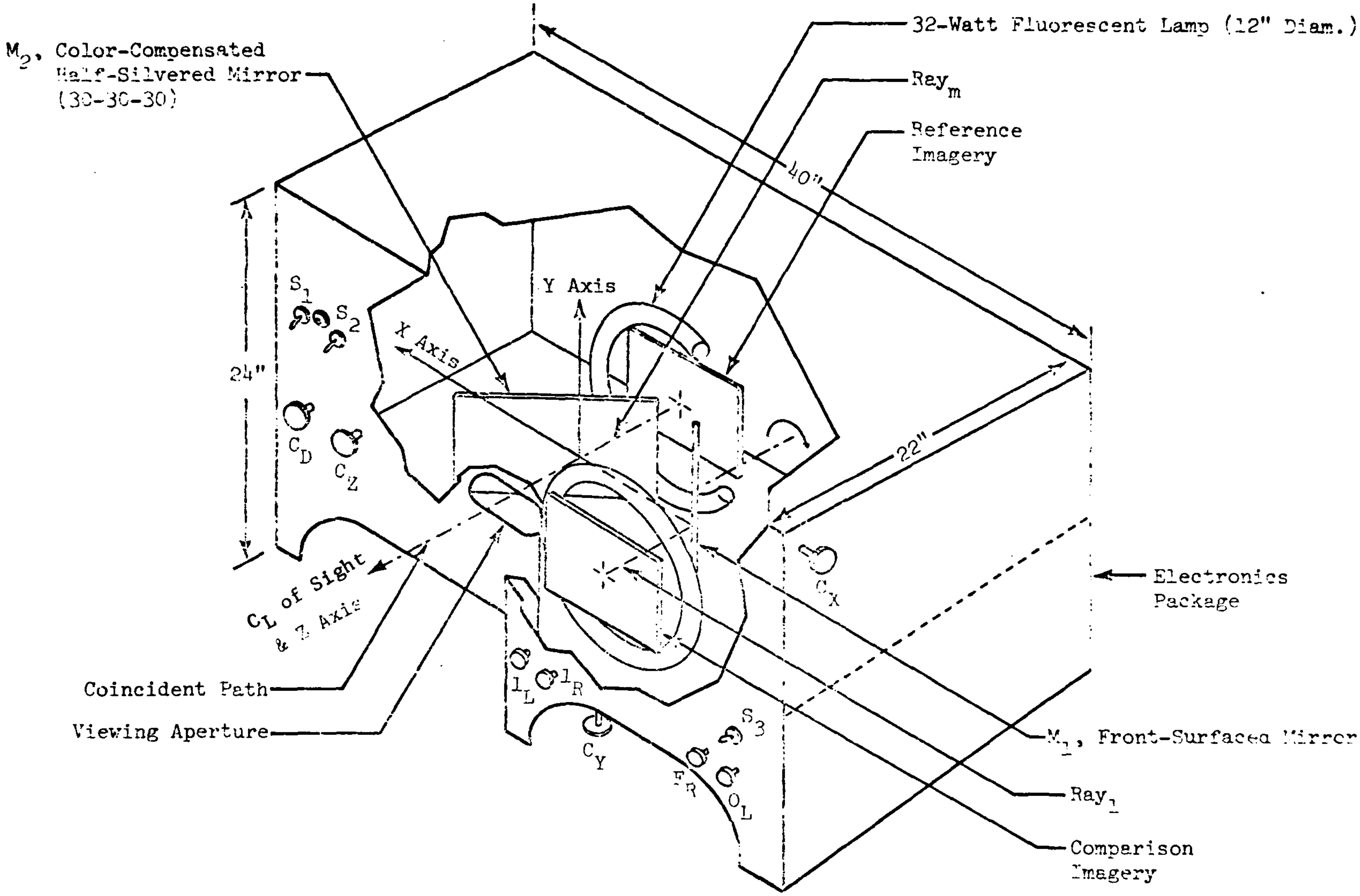

Figure 2. Cutaway schematic of the viewing device.

The timer and counter panel is shown in Figure 3. The timer (located on the left of the panel) determined the maximum exposure time (4 minutes) for each photographic pair. The alternation frequency (which was fixed at 1.5 cycles per second) was checked by a ten-second counter at lower left on the vertical face of the panel. The counter registered the number of alternations in a ten-second period after the adjacent toggle switch had been activated. Three lapsed-time indicators registered total exposure time and time spent viewing each photo of a pair shown in the apparent-motion display mode. The counters for the right and left photos were located directly below their respective lapsed-time indicators.

Exposure of the photographs was initiated by means of a "start" button located on the right side of the front vertical panel of the timing unit. Display could be terminated either by the automatic timer or by the "manual stop" button on the inclined panel.

PROCEDURE

The subjects were informed that the research was part of a larger program being conducted by the Behavioral Science Research Laboratory to study various aspects of the photo-interpretation task for the purpose of determining ways to make it more efficient and effective. They were told that considerable effort was being directed at the more routine aspects of the photo-interpretation task in the hope of reducing the time and effort expended by the experienced photointerpreter on these matters.

The essential aspects of the apparent-motion display equipment were explained, with the aid of a schematic diagram of the optical system. The display equipment was then demonstrated, first in side-by-side presentation and then in apparent motion, with pairs of photos representing a minimum visual noise condition (photos were identical except for specific artificially introduced changes).

Once subjects had been given an opportunity to view the display of photographs under relatively ideal conditions, they were shown sample pairs illustrative of the type of photography to be expected under operational conditions and similar to that which would be presented during the actual testing period. The experimenter pointed out the difficulties of change detection associated with shifts in camera angle resulting from aircraft roll or pitch, scale disparity as affected by altitude, and orientation as affected by aircraft drift.

The photo-interpreters were told that the exposure time of any given pair in the test session would be limited to 4 minutes, but that if they felt they had found all the changes they could before the end of the four-minute exposure period, they should so inform the examiner. They were instructed to relax between presentations of pairs and not to look at the next pair in the series until the signal had been given.

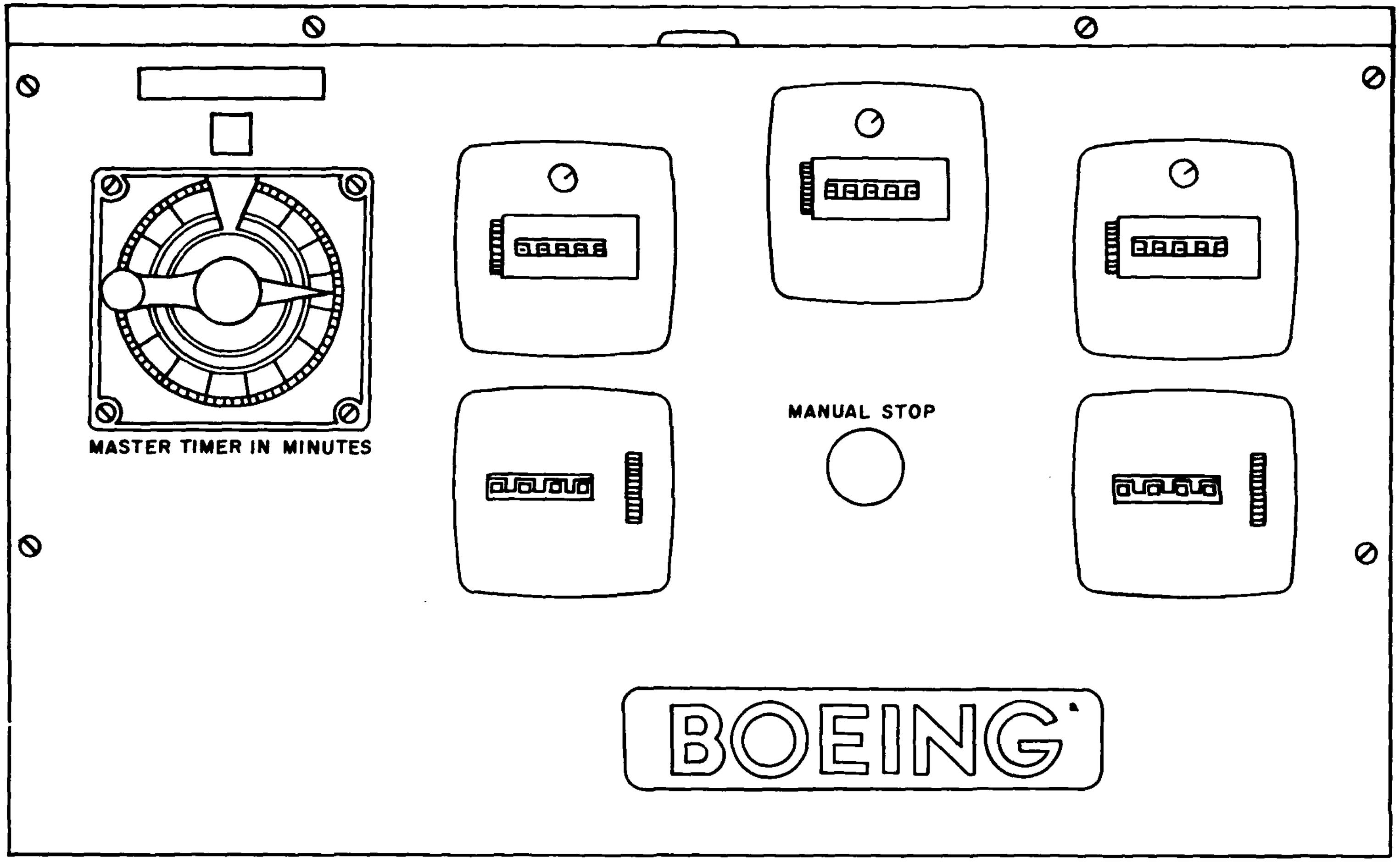

Figure 3. Photograph of timer and counter panel

*Identification of equipment by trade name is in the interest of precision in describing the research procedure and does not constitute indorsement by BESRL or the Department of the Army.

The manner in which they were to respond to the presence of targets which they might find in the photographic pairs was fully explained. In the side-by-side presentation mode, the right photo would represent the earlier coverage and the left photo the later coverage. In the apparent-motion method of display, where the two members of the photographic pair were alternated in spatial registry, provision was made for prolonged viewing of either image.

Instructions to the photo-interpreter included how to report target and location, change status, and subjective confidence level.[2] Target location was indicated by reference to a photo identical to one of those in the pair. This third photo was covered by a grid with numbered cells. The subject was instructed to use this grid photo for location purposes only, not to study it for the presence of targets. Interpreters were cautioned to report the existence of targets and target changes only, and not terrain changes where no target was actually visible. They were told that the number of targets they might expect to find in each pair could range from zero to any number. They were informed that they would view 12 photo pairs, half of which would be presented side by side and half in apparent motion.

Finally, they were told that their individual performance data would not become a part of their permanent military records or be reported to anyone, that these data would be reported only as averages for all subjects. It was emphasized that the goal of the experiment was to evaluate the display systems and not the individual ability of the photo-interpreters who served as subjects.

After each subject has seen all the experimental photo pairs, he was asked to offer a subjective evaluation of the potential utility of the apparent-motion display technique for change detection in comparative-cover aerial reconnaissance photography.

PERFORMANCE MEASURES AND SCORING

The scoring of individual responses was achieved by comparing each report of a target location, identification, and change status against the "interpreter truth" data provided by a team of intelligence and interpretation experts from the U. S. Army Behavioral Science Research Laboratory. The "interpreter truth" information for each target on a given photo pair was encoded and recorded on IBM cards. The responses of each subject were similarly encoded and transcribed to the same cards. Inventive error responses were identified and entered separately. By comparing the transcribed responses of each subject with the interpreter truth data, quantitative data were obtained on 1) number of targets correctly detected (and by

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[2] Confidence level was included to achieve conditions more closely resembling operational image interpretation in which it is common practice for interpreters to state their confidence in their reports on a 5-point scale. Data were not included in the analysis.

subtraction, the number omitted), 2) number of correctly detected targets which were correctly identified, and the number incorrectly identified, 3) number of correct change status assignments and number of incorrect assignments, and 4) number of inventive errors committed, along with the erroneous identifications and change status designations associated with the misidentifications.

Only change detection performance data, with and without target identification, are reported here. Change detection without target identification required only that the interpreter state whether the detected object was a target or a non-target object. He then determined whether the target was present in both photos and, if present, whether its location had changed in the later photo. If a target was determined to be in the same position in both photos, the interpreter had to make a same-different judgment. Applicable change status designations were: Gone, New, Unchanged, Replaced. Thus, erroneous change status reports could result from failure to detect the presence of a target or targets, failure to distinguish between target and non-target objects (and non-objects in the case of inventive errors), failure to translate accurately target locations from photo to photo, and failure to make the correct same-different discrimination.

Change detection performance with target identification required that the interpreter, subsequent to his detection of a potential target object and completion of the target/non-target determination, identify each target. Where individual target objects were uniquely identifiable, it was also possible to apply the change status "Moved" to describe a situation where the specific target item had been repositioned but remained within the same general area. All the sources of erroneous change status assignments cited previously were also applicable to this level of response, plus the errors attributable to misidentification of detected targets.

The method of evaluating interpreter performance placed maximum emphasis on the change detection aspect of the task. Partial credit was not allotted for detection responses made to only one of the two photos (when this incomplete assessment resulted in a wrong change status response). Only when the complete present-absent and same-different comparison was accurately performed could a correct change status be registered.

EVALUATIVE MEASURES

From the response data available, evaluations of interpreter performance were derived for application in assessing the effects of the independent variables. Separate measures of interpreter performance were computed for change status detection without identification of target and for change status detection requiring target identification.

Change Status Completeness. The completeness of interpretation is the ratio of the number of correct change status responses to the total number of correct change status responses possible. In equation form:

$$\text{COMPLETENESS} = \frac{\text{Number of Correct Change Status Responses}}{\text{Total Possible Correct Change Status Responses}}.$$

Change Status Accuracy. The accuracy of interpretation is the ratio of the number of correct change status responses to the total number of change status responses (both correct and incorrect) reported by the interpreter subject. In equation form:

$$\text{ACCURACY} = \frac{\text{Number of Correct Change Status Responses}}{\text{Total Number of Change Status Responses Reported}}.$$

To provide comparable performance measurement units from photo pairs containing different numbers of targets, the completeness and accuracy scores of each subject were averaged over all photo pairs viewed under each experimental condition to yield mean performance figures for each treatment condition.

RESULTS

DATA LIMITATIONS

Treatment of the data was modified to deal with a problem that arose out of the selection of the stimulus material when it was found that four of the twelve photo pairs used contained no military targets. This inadvertence in selecting the test stimuli led to the requirement for some arbitrary decisions in order to fill the cells of the experimental treatment matrices.

There could be, of course, no variation in scores for photo pairs with no targets. A completeness score was defined as the ratio of correct responses to number of targets in a given photo pair. If there were no targets in the pair, the ratio was 0/0. For computation of the accuracy score, the denominator of the no-target pairs would vary, since it could include inventive errors. However, the accuracy score would also be zero. The decision was made to assign completeness and accuracy scores of zero for all such pairs. Since the means were computed for individual pairs rather than for all twelve pairs taken together, the effect of the four no-target pairs was to place an upper limit of 67 percent on both completeness and accuracy mean scores. Discussion of results therefore concentrates on relative performance under the different conditions. Even so, results must be interpreted with a certain amount of reservation.

CHANGE DETECTION COMPLETENESS

Without Target Identification. Table 1 lists mean completeness scores when target identification was not required. The analysis of variance (Appendix Table C-1) indicated that display mode was the only factor significantly influencing this aspect of change detection. The analysis suggests that comparative-cover imagery displayed in apparent motion may yield consistently more complete change detection reports than the same imagery displayed side by side.

With Target Identification. When target identification was added to the change detection task, the mean completeness scores presented in Table 2 were obtained. The analysis of variance, relatively meaningless with the values so badly truncated at the lower end of the performance continuum, revealed no significant F ratios (Appendix Table C-2).

The apparent reason for the extremely low scores when target identification was required relates to the restricted viewing conditions imposed by the display apparatus. Although the range of photographic scales found in this image sample was approximately equivalent to that successfully used in previous change detection studies, the viewing distance with the present display system was fixed at 21 inches. This viewing distance may have created a visual discrimination problem which exceeded the visual resolving capabilities of the observers without benefit of optical aids.

CHANGE DETECTION ACCURACY

Without Target Identification. Mean accuracy scores for change status responses not involving target identification are Presented in Table 3. The analysis of variance (Appendix Table C-3) indicated that only the difference between display modes in favor of apparent motion achieved statistical significance.

Identification Level. No analysis was performed on accuracy scores with target identification required since, as previously discussed, the target identification task was such that this index of performance was not sufficiently sensitive to reflect accurately the effects of the variables under investigation.

ANCILLARY FINDINGS

Inventive Errors. Past research, as previously referenced, suggests that inventive errors are a particularly sensitive measure of the effects of visual noise on change discrimination performance. A separate analysis was performed on inventive errors. Table 4 lists the mean number of errors per photo pair for each treatment combination. The analysis of variance computed indicated no significant performance differences associated with any of the experimental variables (Appendix Table C-4).

Table 1

MEAN COMPLETENESS SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES
WHEN TARGET IDENTIFICATION IS NOT REQUIRED

Side-by-Side Mode

		Scale Discrepancy		
		0%	10%	Means
Orient. Discrepancy	0°	.169	.127	.148
	2°	.259	.143	.201
	4°	.174	.127	.150
	Mean	.200	.132	.166

Apparent-Motion Mode

		Scale Discrepancy		
		0%	10%	Means
Orient. Discrepancy	0°	.280	.193	.236
	2°	.235	.274	.254
	4°	.245	.275	.260
	Mean	.253	.247	.250

Combined Modes

		Scale Discrepancy		
		0%	10%	Means
Orient. Discrepancy	0°	.224	.160	.192
	2°	.247	.208	.228
	4°	.209	.201	.205
	Mean	.227	.190	.208

Table 2

MEAN COMPLETENESS SCORES FOR CHANGE DETECTION RESPONSES WHEN TARGET IDENTIFICATION IS REQUIRED

Side-by-Side Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.015	.039	.027
2°	.015	.017	.016
4°	.033	.019	.026
Mean	.021	.025	.023

Apparent-Motion Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.020	.029	.025
2°	.029	.027	.028
4°	.015	.018	.016
Mean	.021	.024	.023

Combined Modes

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.018	.034	.026
2°	.022	.022	.022
4°	.024	.018	.021
Mean	.021	.025	.023

Table 3

MEAN ACCURACY SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES
NOT REQUIRING TARGET IDENTIFICATION

Side-by-Side Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.241	.197	.219
2°	.372	.297	.334
4°	.270	.148	.209
Mean	.295	.214	.254

Apparent-Motion Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.362	.378	.370
2°	.370	.338	.354
4°	.400	.298	.349
Mean	.377	.338	.358

Combined Modes

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	.301	.288	.294
2°	.371	.317	.344
4°	.335	.223	.279
Mean	.336	.276	.306

Table 4

MEAN NUMBER OF INVENTIVE ERRORS PER PHOTO PAIR

Side-by-Side Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	2.25	2.67	2.46
2°	1.67	1.96	1.81
4°	2.38	3.29	2.83
Mean	2.10	2.64	2.37

Apparent-Motion Mode

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	3.21	2.79	3.00
2°	2.83	2.00	2.42
4°	2.04	3.38	2.71
Mean	2.69	2.72	2.71

Combined Modes

Orient. Discrepancy	Scale Discrepancy 0%	Scale Discrepancy 10%	Means
0°	2.73	2.73	2.73
2°	2.25	1.98	2.11
4°	2.21	3.33	2.77
Mean	2.40	2.68	2.54

Viewing Time. The mean inspection time per photo pair when displayed side by side was 166 seconds. The corresponding mean for the apparent-motion display was 177 seconds. A sign test was made of the differences in inspection time for the two displays; fourteen subjects used more time on the apparent-motion display while ten used less. Those subjects who spent more time with one type of display worked longer with the other ($r = +.58$, $\sigma_r = .14$). Subjects who spent more time on the task did not necessarily provide more change detections ($r = +.12$, $\sigma_r = .20$) but tended to make more inventive errors ($r = +.53$, $\sigma_r = .15$).

Performance Predictors. A correlation computed between the General Technical Aptitude Area scores of the 24 subjects and their target detection performance yielded an insignificant coefficient of + .05 ($\sigma_r = .20$). A similar comparison between months of interpreter experience and detection performance resulted in an equally insignificant correlation coefficient of + .18 ($\sigma_r = .20$).

Subjective Evaluation Data. The group of 24 experienced image interpreters who had performed with the apparent-motion display generally expressed the opinion (21 out of 24) that this technique showed definite promise for enhancing change-detection performance (see tabulated responses in Appendix D). However, the stated or implied content of their remarks was obviously of restricted application, that is, concerned with simple change detection without such relatively complex operations as measurement of objects on the ground.

CONCLUSIONS

While the experimental design applied to this investigation may have provided for adequate comparison between side-by-side and apparent-motion display systems, the sample of photographic pairs employed did not fulfill the requirements for the planned analysis. Obvious reduction in the strength of the test (attributable to the lack of targets in four of the twelve photo-pairs) notwithstanding, the performance data obtained from the 24 experienced image interpreters engaging in the target change detection task support the following conclusions:

1. Significantly improved target change detection performance, in terms of both accuracy and completeness, can be achieved by displaying comparative-cover aerial photography in an apparent-motion, as opposed to a conventional side-by-side, mode.

2. The superior performance possible with an apparent-motion display system can be obtained with essentially the same amount of interpretation time as would be required for a lesser performance level with a side-by-side display.

3. Relatively small amounts of either scale disparity or orientational misalignment will not significantly degrade interpreter performance on change detection tasks with either type of display system.

4. Subjective opinions provided by experienced image interpreters indicated good user acceptance of the apparent-motion concept as applied to the change detection problem.

APPENDIXES

APPENDIX A

Table A-1

LATIN SQUARE MATRICES FOR ASSIGNMENT OF TREATMENTS TO SUBJECT X PHOTO-PAIR COMBINATIONS

Subject Number

PHOTO-PAIR NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
1	1	2	3	4	9	10	11	12	5	6	7	8
2	2	1	4	3	10	9	12	11	6	5	8	7
3	3	4	1	2	11	12	9	10	7	8	5	6
4	4	3	2	1	12	11	10	9	8	7	6	5
5	5	6	7	8	1	2	3	4	9	10	11	12
6	6	5	8	7	2	1	4	3	10	9	12	11
7	7	8	5	6	3	4	1	2	11	12	9	10
8	8	7	6	5	4	3	2	1	12	11	10	9
9	9	10	11	12	5	6	7	8	1	2	3	4
10	10	9	12	11	6	5	8	7	2	1	4	3
11	11	12	9	10	7	8	5	6	3	4	1	2
12	12	11	10	9	8	7	6	5	4	3	2	1

Subject Number

PHOTO-PAIR NUMBER	13	14	15	16	17	18	19	20	21	22	23	24
1	1	12	6	7	5	4	10	11	9	8	2	3
2	2	11	5	8	6	3	9	12	10	7	1	4
3	3	10	8	5	7	2	12	9	11	6	4	1
4	4	9	7	6	8	1	11	10	12	5	3	2
5	5	4	10	11	9	8	2	3	1	12	6	7
6	6	3	9	12	10	7	1	4	2	11	5	8
7	7	2	12	9	11	6	4	1	3	10	8	5
8	8	1	11	10	12	5	3	2	4	9	7	6
9	9	8	2	3	1	12	6	7	5	4	10	11
10	10	7	1	4	2	11	5	8	6	3	9	12
11	11	6	4	1	3	10	8	5	7	2	12	9
12	12	5	3	2	4	9	7	6	8	1	11	10

APPENDIX B

Table B-1

DISTRIBUTION OF TARGETS WITHIN PHOTO-PAIR SAMPLE SELECTED

Pair No.	Photo Ident. No.	Days Elapsed	No. of Targets	Target Distribution by Target Categories									Distribution by Change Status				
				1	2	3	4	5	6	7	8	9	U	M	N	G	R
1	D-20/78 D-04/67	1	24				5	3			16		11		9	4	
2	D-23/03 D-37/28	721	0														
3	D-35/101 D-45/61	6	4				4								3	1	
4	D-64/18 D-64/25	0	2				2								1	1	
5	D-64/18 D-64/25	0	2				1	1					1	1			
6	D-37/39 D-54/08	5	4				1	1		2				1	1	2	
7	D-29/52 D-45/68	9	3			1	2								3		
8	D-35/101 D-45/61	6	11	2		1	3	1	4						11		
9	D-35/101 D-45/61	6	0														
10	D-64/18 D-64/25	0	4				4						2		1	1	
11	D-35/101 D-45/61	6	0														
12	D-64/18 D-64/25	0	0														
Total			54	2	0	2	22	6	4	2	16	0	14	2	29	9	0

APPENDIX B

Table B-2

PHOTO CHARACTERISTICS OF STIMULUS SAMPLE

Photo Pair	Photo Identification Number	Date	Quality	Original Scale	Percent Common Area
1	D-20/78	7 Sept 62	G	5000	
	D-04/67	8 Sept 62	G	9000	55
2	D-23/03	12 Sept 62	G	2400	50
	D-37/28	3 Sept 64	F	3500	
3	D-35/101	2 Sept 64	F	2800	100
	D-45/61	8 Sept 64	F	3100	
4	D-64/18	Feb 65	G	4000	95
	D-64/25	Feb 65	G	4000	
5	D-64/18	Feb 65	G	4000	95
	D-64/25	Feb 65	G	4000	
6	D-37/39	3 Sept 64	F	3000	
	D-54/08	8 Sept 64	F	5000	65
7	D-29/52	31 Aug 64	G	2800	
	D-45/63	8 Sept 64	G	2300	85
8	D-35/101	2 Sept 64	F	2800	
	D-45/61	8 Sept 64	F	3100	100
9	D-35/101	2 Sept 64	F	2800	
	D-45/61	8 Sept 64	F	3100	100
10	D-64/18	Feb 65	G	4000	95
	D-64/25	Feb 65	G	4000	
11	D-35/101	2 Sept 64	F	2800	
	D-45/61	8 Sept 64	F	3100	100
12	D-64/18	Feb 65	G	4000	95
	D-64/25	Feb 65	G	4000	

APPENDIX C

Table C-1

COMPLETENESS SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES NOT REQUIRING TARGET IDENTIFICATION

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Mode (A)	.507	1	.507	12.49**
Orientation (B)	.062	2	.031	.77
Scale (C)	.099	1	.099	2.43
AxB	.038	2	.019	.47
BxC	.037	2	.019	.46
AxC	.070	1	.070	1.73
AxBxC	.123	2	.062	1.52
Residual	9.828	242	.041	---
(photo pair)	8.498	11	---	---
(subjects)	1.940	23	---	---
(mean)	12.486	1	---	---
Total	33.688	288		

**$P < .01$

APPENDIX C

Table C-2

COMPLETENESS SCORES FOR CHANGE DETECTION RESPONSES REQUIRING TARGET IDENTIFICATION

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Mode (A)	.000	1	.000	.00
Orientation (B)	.001	2	.001	.22
Scale (C)	.001	1	.001	.31
AxB	.006	2	.003	.94
BxC	.006	2	.003	1.02
AxC	.000	1	.000	.00
AxBxC	.003	2	.002	.57
Residual	.725	242	.003	---
(photo pair)	.579	11	---	---
(subjects)	.070	23	---	---
(mean)	.151	1	---	---
Total	1.543	288		

APPENDIX C

Table C-3

ACCURACY SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES
WITHOUT TARGET IDENTIFICATION

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Mode (A)	.769	1	.769	10.11**
Orientation (B)	.221	2	.111	1.45
Scale (C)	.258	1	.258	3.39
AxB	.256	2	.128	1.68
BxC	.116	2	.058	.77
AxC	.031	1	.031	.41
AxBxC	.005	2	.002	.03
Residual	18.396	242	.076	---
(photo pair)	16.430	11	---	---
(subjects)	5.229	23	---	---
(mean)	26.942	1	---	---
Total	68.652	288		

**P < .01

APPENDIX C

Table C-4

INVENTIVE ERRORS

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Mode (A)	8.337	1	8.337	1.42
Orientation (B)	25.924	2	12.962	2.20
Scale (C)	5.837	1	5.837	.99
AxB	7.840	2	3.920	.67
BxC	26.299	2	13.149	2.23
AxC	4.753	1	4.753	.81
AxBxC	8.049	2	4.024	.68
Residual	1425.510	242	5.891	---
(photo pair)	1099.200	11	---	---
(subjects)	753.830	23	---	---
(mean)	1855.420	1	---	---
Total	5221.000	288		

APPENDIX D

Table D-1

SUMMARY OF OPINIONS SOLICITED FROM SUBJECTS

Comment	No. of Times Voiced
Good for Change Detection	21
Needs Magnification for Identification	9
Grid System Needed in Machine	5
Scale and Orientation Differences Tolerable	5
Scale and Orientation Differences Detracted	4
Would Like Stereo	4
Stereo Not Needed	3
Needs Different Eyepiece	2
Prefer Side-by-Side Presentation	1